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EUROPEAN PATENT APPLICATION

(21) Application number: 94306649.8

(51) Int. Cl.<sup>6</sup>: H03D 7/16

(22) Date of filing: 09.09.94

(30) Priority: 10.09.93 FI 933989

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(43) Date of publication of application:  
15.03.95 Bulletin 95/11

Geologintie 6

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(84) Designated Contracting States:  
CH DE ES FR GB IT LI SE

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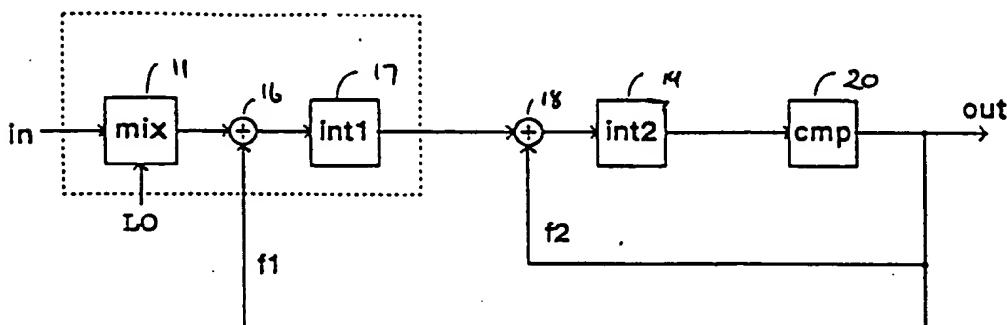
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(54) Demodulation of an IF-signal by a sigma-delta converter.

(57) A sigma-delta signal converter is implemented using switched capacitor switching elements in which a first switch (31) serves as a mixer (11). The output of the mixer is directed to the second input of an adder (16), and its second input is the feedback signal (f1) of the sigma-delta signal converter, which is also directed into a base-frequency output signal through a decimator (14) and low-pass filtering (15).



EP 0 643 477 A2

Fig. 3

The invention relates to a receive arrangement for receiving a modulated carrier signal.

EP 0 461 720-A1 describes a known receive arrangement for receiving a modulated carrier signal, comprising a mixer/demodulator driven with a sinusoidal oscillator of carrier frequency  $f_c$ , at least one adder, a low-pass filter, a pulse shaper constituting a one-bit sigma-delta signal converter, all included in a closed signal loop, the pulse shaper being driven with sampling frequency  $f_s$ , and further comprising a digital decimation filter. In this type of receive arrangement the modulated carrier signal is demodulated in the closed signal loop by the mixer/demodulator, the output signal of which is converted after passing through the low-pass filter into a digital signal by the sigma-delta converter.

A typical prior art sigma-delta converter arrangement is described in greater detail with reference to Figure 1 of the drawings.

An incoming intermediate frequency IF carrier signal is provided to each branch of the receive arrangement. In each branch the incoming signal is filtered through bandpass filter 1 and mixed to a baseband signal in a linear mixer 2 using a sinusoidal local oscillator signal LO1 at the IF frequency. A high time constant capacitor 3 is provided on each of the incoming signal branches to remove direct currents from the baseband signal. The gain of the circuit is controlled through Automatic Gain Controllers (AGC) 5 and the baseband signals are converted to digital signals in modulators 6. After modulation the signals pass through respective decimators 7 and post filters 8 to remove spurious signals created by the decimators. The specific details of the local oscillator frequency and phase shifts of the particular arrangement illustrated in Figure 1 are as follows:

$$\text{PHI1} = +45^\circ$$

$$\text{PHI2} = -45^\circ$$

$$\text{PHI3} = \text{PHI4} = 0^\circ$$

$$\text{LO1} = \text{IF}$$

LO2 = oversampling frequency

The demodulation, i.e., the mixing of the intermediate frequency (bandpass-filtered) int-signal down to the base frequency is traditionally based on the use of a multiplier. Thus the modulated IF-signal is multiplied by the sinusoidal oscillator signal (LO1). In the synchronous demodulation the frequency and the phase of the oscillator are locked to the carrier wave with the aid of a phase-locked loop (PLL), for instance. The frequency spectrum of the mixed product consists of the desired base-frequency component and the component spectrums which are removed by low-pass filtering prior to entering the sigma-delta converter. Such a mixing process may be described by the following trigonometric equation:

$$\cos(a) \cdot \cos(b) = 1/2 \cdot \cos(a - b) + 1/2 \cdot \cos(a + b) \quad (1)$$

Equation (1) holds only if both products are pure

cosine signals.

If  $\cos(a)$  now represents the modulated int-carrier wave then:

$$a = \omega_0 \cdot t + \text{PHI}, \quad (2)$$

where  $\omega_0$  is the angle frequency of the carrier wave and PHI is a momentary phase modulation (QAM, MSK, QPSK, GMSK, ...).

Ideally the term  $\cos(b)$  represents a clean, mixing oscillator frequency (LO):

$$b = n \cdot \omega_1 \cdot t \quad (n = 1, 2, 3, \dots) \quad (3)$$

where  $n \cdot \omega_1$  is the angular frequency of the oscillator of the mixer.

In the ideal case the frequency and the phase of the oscillator are locked to the frequency and the phase of the carrier wave of the input signal (in). In these conditions  $\omega_0 = n \cdot \omega_1$ , and the term  $1/2 \cdot \cos(a - b)$  is reduced to  $1/2 \cdot \cos(\text{PHI})$ . This base-frequency phase difference signal conveys the data symbols. Term  $1/2 \cdot \cos(a + b)$  represents the component of the frequency spectrum on frequency  $2 \cdot \omega_0$ .

When prior art receive arrangements such as those described above are implemented by discrete components they require a very large area on the printed circuit board. In addition, as the signal entering the sigma-delta converter is a baseband signal the ac-coupled branches need very high high-pass corner frequencies with high time constants in order to accomplish dc blocking. This means that it is not efficient for the arrangement to be powered down as often as would be ideal, as powering up again is slow and as a result the circuit cannot be powered down for short periods. The circuit therefore, consumes a large amount of power.

In accordance with the present invention there is provided a receiver for receiving a modulated carrier signal comprising, a sigma-delta signal converter having at least one adder included in a feedback loop, characterised in that the arrangement comprises a time discrete sampling means for down converting the modulated carrier signal prior to the feedback loop.

By down converting the carrier frequency signal using a time discrete sampling means a number of advantages are provided. Firstly, an expensive sinusoidal oscillator is no longer required with space and cost benefits. Secondly, although use of time discrete sampling means, rather than a pure sinusoidal local oscillator for down converting the IF signal means that mixing occurs at the frequency of sampling and also at harmonics of the sampling frequency this perceived disadvantage can be used to the system's advantage enabling samples to be taken using a local oscillator sampling at a subharmonic frequency of the carrier signal. Thus can also give important power savings.

One way in which the invention can be implemented is by using the input stage of a sigma-delta signal converter having switched capacitor switching

elements to implement the time discrete sampling means that acts as a mixer. The sigma-delta converter with the desired switched capacitor switching elements provided at the input stage may as an ASIC. The output of this mixer can then be directed to the first input of an adder included in the closed feedback signal loop of the sigma-delta converter. This adder comprises, as the second input, the feedback signal of the sigma-delta signal converter, which is also directed through a decimator and low-pass filter to provide an output signal which is provided to the second input of the adder.

In circuits of embodiments of the invention the incoming modulated signal may be mixed into a base-band frequency signal or a frequency approaching the base-band frequency prior to entering the closed feedback loop.

Sigma-delta converters are traditionally used in converting base-band signals. However, in accordance with to the invention, they can now be adapted for converting intermediate frequency signals directly.

Difficult ac-coupling problems, control and high-pass filtering problems are solved by circuit arrangements of embodiments of the invention. Similarly, power consumption can be decreased by shortening the time for switching the receiver on from stand-by to the active state. This enables the circuit to be powered down when not in use for shorter periods than would conventionally be possible as a capacitance with a lower time constant is adequate for dc blocking.

An additional advantage can be gained by using switched capacitors to provide some of the automatic gain control of the circuit. This means that the number of AGC-circuits required by the receive arrangement as a whole can be decreased. With embodiments of the invention part of the necessary filtering can also be provided without the need for additional filters between the mixing and a-d converting stages by utilising a digital filter already present in the sigma-delta converter.

Embodiments of the invention can be utilized advantageously in, for example, radio telephones.

Embodiments of the invention will now be described in greater detail with reference to Figures 2 to 4 of the drawings of which:

Figure 2 is a block diagram of a sigma-delta converter included in a receive arrangement according to one embodiment of the invention;

Figure 3 is a schematic representation of a switched capacitor switching element suitable for implementing the mixing and automatic gain control functions of the embodiment of Figure 2; and Figure 4 is a schematic representation of an embodiment of a receive arrangement including the sigma-delta converter of Figure 2 operating with a local oscillator at or near the carrier frequency of the incoming signal.

The receive arrangement of an embodiment of the invention is illustrated in Figure 2 using a sigma-delta analog-digital converter with a large dynamic input range in which a mixer 11 is implemented using switched capacitor switching elements 30-39 illustrated in Figure 4. The switched capacitor switching elements providing the mixing function of the mixer 11 are driven by a square wave local oscillator signal (LO1) at (or near) the frequency of the IF signal. Both the mixer and the local oscillator signal are digital. Switched capacitor switching elements are also provided to implement an automatic gain controller (AGC) 12 providing an automatic gain control function for the circuit. The receive arrangement includes a bandpass filter 10, and each branch further includes a modulator 13 that converts signals from analog signals to digital signals, a decimator 14 and a post filter 15 which perform the same functions as the correspondingly named portions of the prior art receive arrangement illustrated in Figure 1. The prefiltering of the signal (after modulation) can be designed to freely correspond to the design demands of the respective circuit and the dc-deviation of the sigma-delta converter can be corrected using the internal, digital correction of deviations.

The phase and frequency details for the local oscillator signals provided to the respective branches are as follows:

$$\text{PHI3} = +45^\circ$$

$$\text{PHI4} = -45^\circ$$

$$\text{LO1} = \text{IF}$$

A base-frequency output signal is obtained from the modulator after the decimator and the low-pass filter which can be processed to retrieve the modulating information. Because the signal entering the sigma-delta converter arrangement is an IF signal, only a short time-constant capacitor 9 is necessary for preventing dc signals from transferring to the sigma-delta converter. This means that the device can be powered up and down more quickly and as less power is required to power up, short term power downs are practical making the arrangement more power efficient than conventional receive arrangements.

The mixer 11, AGC 12 and modulator 13 are described in greater detail with reference to Figure 3. The modulated reception signal (in), for instance a bandpass-filtered int-signal from the RF-part of the radio telephone, is directed to the mixer 11 (mix) to which the local oscillator (LO1) signal is also applied. LO1 may be on or around the carrier frequency of the received signal (in) or a subharmonic of that frequency. The output of mixer 11 is directed to a first adder 16, the second input of which is a feedback signal f1. The output of the first adder 16 is directed to an integrator 17. The output of the integrator 17 is directed to a second adder 18, the second input of which is a feedback signal f2. The output of the second adder 18 is directed to a second integrator 19 and further to a

comparator 20. The output signal (out) of the comparator 20 is further directed to the decimator 14 the (low-pass) post filter 15 for filtering out unwanted signals resulting from mixing of LO1 and the carrier signal.

The output signal provides a base-frequency signal which can be processed using digital signal processing means, for instance. The output signal (out) is coupled to the first and second adders (f1) and 18 (f2) in respective feedback branches.

The second adder 18, the second integrator 19 (int2) and the comparator 20 (cmp) provide a second closed feedback loop in the circuit. Those skilled in the art know the basic idea of the sigma-delta converter, therefore it is not described in more detail in this connection. More detailed discussion can be found in the articles: The Design of Sigma-Delta Modulation Analog-to-Digital Converters, Bernhard E. Boser, Bruce A. Wooley, IEEE Journal of Solid-State Circuits, Vol. 23 No.6 December 1988 and Oversampling Delta-Sigma Data Converters, Theory, Design and Simulation J.C. Candy and G.C. Temes IEEE press 1992 both incorporated herein by reference.

Typically in the prior art an analogue bandpass filter is provided prior to entering the modulation stage of the sigma-delta converter to remove unwanted signals resulting from mixing. In the present case, however, the digital filtering function of the sigma-delta converter itself can be used to remove the unwanted signals.

Figure 4 shows the input stage of the receive arrangement of the embodiment of Figure 2 showing switched capacitor switching elements of the mixer 11 and the AGC 12 in greater detail. A first capacitor 30 is used to sample and hold the incoming signal. First switches 31, 32 are closed to provide a sample to the first capacitor 30. Once the input signal has been sampled, a third switch 33 is closed to transfer the charge on the first capacitor 30 to the output. Second and third (and possibly further) capacitors 34, 35 are provided in parallel with the first capacitor 30. These are each controllably connected to the input and output through a pair of switches 36, 37; 38, 39. By closing the appropriate switches and adding parallel capacitance from one or more of the second and third capacitors 34, 35 the signal transfer ratio can be changed. The switches are under the control of an external cpu and can be used to replace automatic gain control steps of the circuit as a whole. In this way amplification steps can be included in the sigma-delta modulator by altering the ratios of the input capacitances.

The mixer 11 can be considered as a sample and a hold circuit that samples the input signal in synchronization with the oscillator and directs the samples to the output as a signal which remains constant for the period of the sampling interval. The oscillator signal (LO) is therefore represented by a square wave

with a base frequency of  $n \cdot \omega_1$ . Instead of the term  $\cos(b) = \cos(n \cdot \omega_1 \cdot t)$  of equation (1), the following series of odd harmonics is obtained:

$$\begin{aligned} 5 & \cos(n \cdot \omega_1 \cdot t) + 1/3 \cdot \cos(3 \cdot n \cdot \omega_1 \cdot t) + \\ & 1/5 \cdot \cos(5 \cdot n \cdot \omega_1 \cdot t) + \dots \quad (4) \end{aligned}$$

The cosine terms of a higher order are mixed in the mixer (1) with the input signal (in) producing sum and difference components of the frequencies to the spectrum of the output signal of the mixer (1). All input signals on a higher frequency than the base frequency are filtered by a filter before entering the mixing stage of the sigma-delta converter.

It is preferable to use the first switch 1 of the switched capacitor switching element as the mixing element. In this case, signal bands around the multiples of the frequency of the local oscillator signal LO are folded onto the base frequency. The local oscillator base frequency or its subharmonics can therefore be used to down convert the carrier signal to the baseband or a frequency approaching the base-band. The unwanted signals resulting from mixing using the local oscillator are removed by filtering.

Referring back to Fig. 2, the inventive idea is realized in the circuit arrangement of this embodiment of the invention in accordance with which switched capacitor switching elements present in the input stage of a sigma-delta converter are used to implement the mixer 11 which directly demodulates the IF-signal into a base-frequency signal; in other words, the IF-signal and its multiples are folded on the base frequency. The first switch 31 in the input of stage of the sigma-delta converter is utilized here to serve as the mixer 11.

The embodiment of Figures 2 to 4 can be implemented using a local oscillator having a frequency LO1 that is the same as or approaching the frequency of the IF carrier signal. Although it would generally be desirable for LO1 to have the same frequency as the incoming signal it may in many instances be desirable or merely practical to use a local oscillator frequency LO1 offset slightly from the frequency of the IF carrier signal. The mixing frequency could, for instance, be  $LO + \Delta f$  (where LO is the frequency of the IF carrier). In this case the signal (in) applied to the input is folded to the frequency  $\Delta f$  which is almost to the baseband frequency. If the modulated intermediate frequency (in) is 1010 kHz, the mixing signal  $LO + \Delta f$  may be 900 kHz, for instance, whereby the demodulated signal is on the frequency of -110 kHz with respect to the baseband frequency.

One example of when it may be practical to use a local oscillator with a frequency slightly offset from the IF carrier frequency is when a driver conveniently located in the sigma-delta converter for providing a square wave local oscillator for driving the mixer 11 does not coincide exactly with the IF carrier signal. Another example is when it is desirable to provide four times oversampling. Under these circumstances the

subsequent digital mixer can be implemented more easily when the signals are at a frequency  $\Delta f$  offset from the baseband. Typically a signal within 1 MHz of the carrier frequency is acceptable for down converting the incoming signal.

In a conventional arrangement, if the mixing frequency of a sinusoidal local oscillator differs from the IF carrier signal by  $\Delta f$ , the term  $\cos(b)$  of equation (1) is solved by the following formula:

$$b = n * \omega_1 * t + \Delta\omega * t, \quad (5)$$

where  $\Delta\omega$  is the angular frequency corresponding to frequency  $\Delta f$ .

Although equation (1) deals with the mathematics of the prior art solution using a sinusoidal local oscillator, once the down converted signal generated by mixing using the time discrete sampler of embodiments of the present invention is filtered prior to entering the a-d modulation stage, it is effectively a pure cosine signal and equation (1) holds.

The receive arrangement of Figures 2 to 4 can also be used to down convert the incoming signal to the baseband (or a frequency approaching the baseband) using a subharmonic of the carrier frequency. In these circumstances the phase and frequency details for the local oscillator signals provided to the respective branches are as follows:

$$\text{PHI3} = +45^\circ$$

$$\text{PHI4} = -45^\circ$$

$$\text{LO1} = \text{IF/N}$$

In other respects the arrangement operates in the same manner as previously described.

When the input signal (in) is branched into two different branches, it is possible to arrange the receive circuit arrangements of embodiments of this invention in each of the branches. The demodulation of an I/Q-modulated signal (I = in the phase, Q = in the phase shift of 90 degrees) may be implemented simply in this way using principles known per se and described by way of example in Digital Communication, Edward A. Lee, David G. Messerschmitt, Kluwer Academic Publishers, Boston, 1990 incorporated herein by reference. The clocks of the modulators of both branches are synchronized.

Those skilled in the art will notice that the circuit arrangements of embodiments of the invention are simple to implement using relatively few circuit elements. They result in decreased power consumption and accelerated operation of the circuit (fast shifting from the stand-by state to the active operating state and vice versa) which is especially significant for radio telephones.

The present invention includes any novel feature or combination of features disclosed herein either explicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed.

In view of the foregoing description it will be evident to a person skilled in the art that various modifi-

cations may be made within the scope of the invention.

## 5 Claims

1. A receiver for receiving a modulated carrier signal comprising, a sigma-delta signal converter having at least one adder included in a feedback loop, characterised in that the arrangement comprises a time discrete sampling means for down converting the modulated carrier signal prior to the feedback loop.

10 2. An electronic receive arrangement according to claim 1 wherein the time discrete sampling structure comprises a switching member under the control of a square wave signal.

15 3. An electronic receive arrangement according to claim 2 wherein the frequency of the square wave signal is the carrier signal frequency or a subharmonic of the carrier signal frequency.

20 4. An electronic receive arrangement according to claim 2 wherein the frequency of the square wave frequency is selected so that the frequency of the down converted signal is intermediate the carrier frequency and the frequency of the baseband signal.

25 5. An electronic receive arrangement according to any preceding claim wherein the time discrete sampling means comprises switched capacitor switching elements.

30 6. An electronic receive arrangement for receiving a modulated carrier signal, the arrangement comprising a sigma-delta signal converter, a mixer/demodulator controlled on the carrier frequency or its subharmonic frequency or on a frequency at least close to these, and at least one adder included in a closed signal loop, characterized in that the received, modulated carrier signal (in) is first directed to the input stage (10) of the sigma-delta signal converter which is implemented as a time discrete sampling structure, the first member (1) of which serves as the mixer, that the output of the mixer is directed to the first second input of said adder (3) and that the second input (f1) of the adder (3) is the feedback signal (out) of the sigma-delta signal converter, whereby the output signal (out) is directed into a base-frequency output signal through a decimator and low-pass filtering.

35 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 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2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 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7245 7250 7255 7260 7265 7270 7275 7280 7285 7290 7295 7300 7305 7310 7315 7320 7325 7330 7335 7340 7345 7350 7355 7360 7365 7370 7375 7380 7385 7390 7395 7400 7405 7410 7415 7420 7425 7430 7435 7440 7445 7450 7455 7460 7465 7470 7475 7480 7485 7490 7495 7500 7505 7510 7515 7520 7525 7530 7535 7540 7545 7550 7555 7560 7565 7570 7575 7580 7585 7590 7595 7600 7605 7610 7615 7620 7625 7630 7635 7640 7645 7650 7655 7660 7665 7670 7675 7680 7685 7690 7695 7700 7705 7710 7715 7720 7725 7730 7735 7740 7745 7750 7755 7760 7765 7770 7775 7780 7785 7790 7795 7800 7805 7810 7815 7820 7825 7830 7835 7840 7845 7850 7855 7860 7865 7870 7875 7880 7885 7890 7895 7900 7905 7910 7915 7920 7925 7930 7935 7940 7945 7950 7955 7960 7965 7970 7975 7980 7985 7990 7995 8000 8005 8010 8015 8020 8025 8030 8035 8040 8045 8050 8055 8060 8065 8070 8075 8080 8085 8090 8095 8100 8105 8110 8115 8120 8125 8130 8135 8140 8145 8150 8155 8160 8165 8170 8175 8180 8185 8190 8195 8200 8205 8210 8215 8220 8225 8230 8235 8240 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9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750

tially a switching member which is directed by a square wave signal on the carrier frequency (LO) or on its subharmonic (LO/n) frequency, whereby the signal (in) applied to the input is folded on the base frequency.

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8. A receive arrangement according to claim 6 or 7, characterized in that the mixing frequency (LO) is replaced by frequency  $LO + \Delta f$ , whereby the signal (in) applied to the input is folded on a nearly base-frequency intermediate frequency  $\Delta f$ .
9. A receive arrangement according to claims 6, 7 or 8, characterized in that said input stage (10) is implemented using components of a switched capacitor integrator.
10. A receive arrangement according to any preceding claim characterized in that the sigma-delta converter comprises at least one adjustable amplification step for automatic gain control (AGC).
11. An IQ-mixer/demodulator in which the input signal is divided into two branches I (in phase) and Q (quadrature), respectively, characterized in that the receive arrangement according to any of the preceding claims is used in both branches.
12. A receive arrangement according to claim 11, characterized in that the required phasing arrangement is either made for the input signal (in), the local one (LO), or for both of them.
13. The utilization of the receive arrangement according to any of the preceding claims in a radio telephone.

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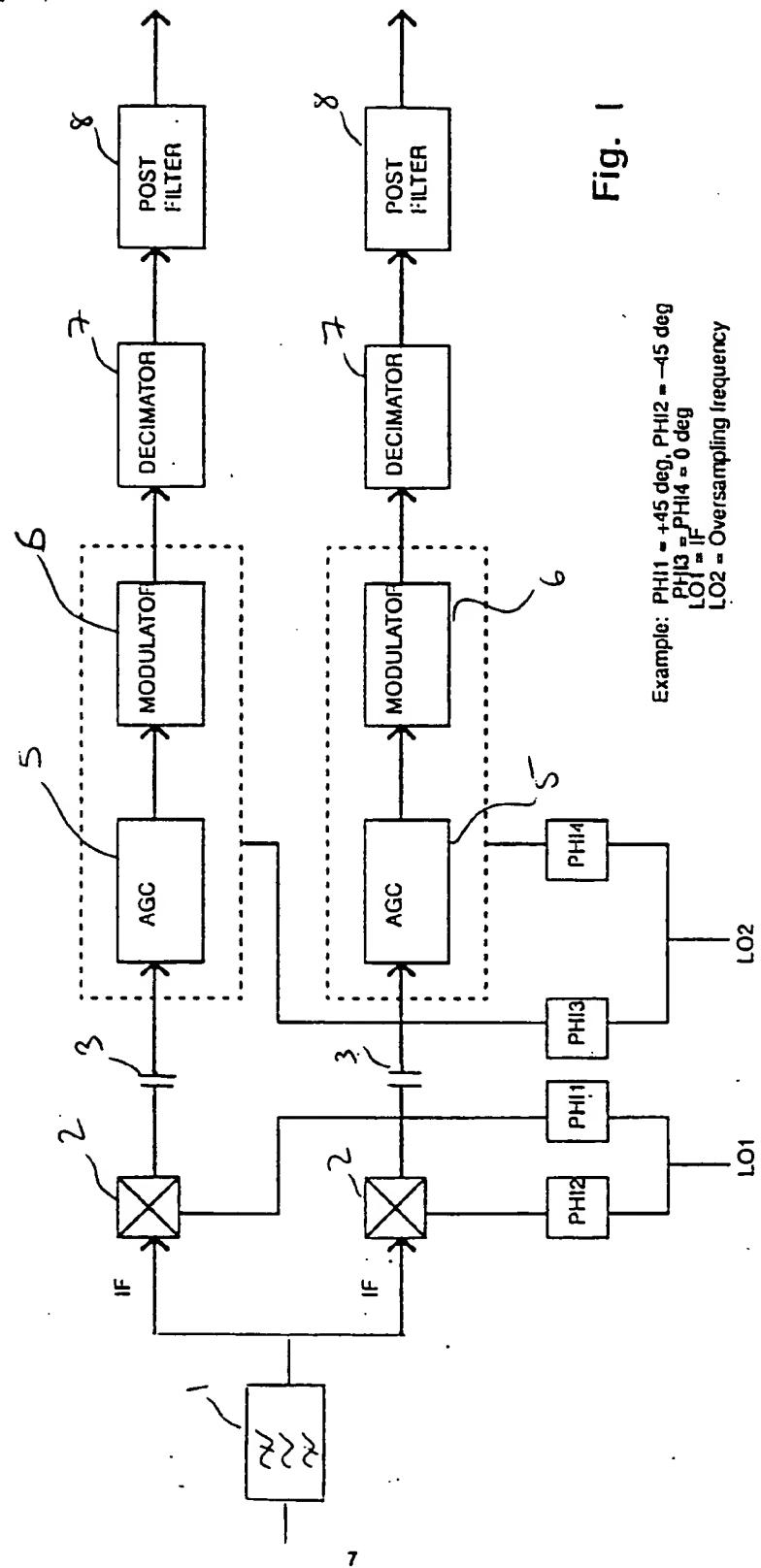
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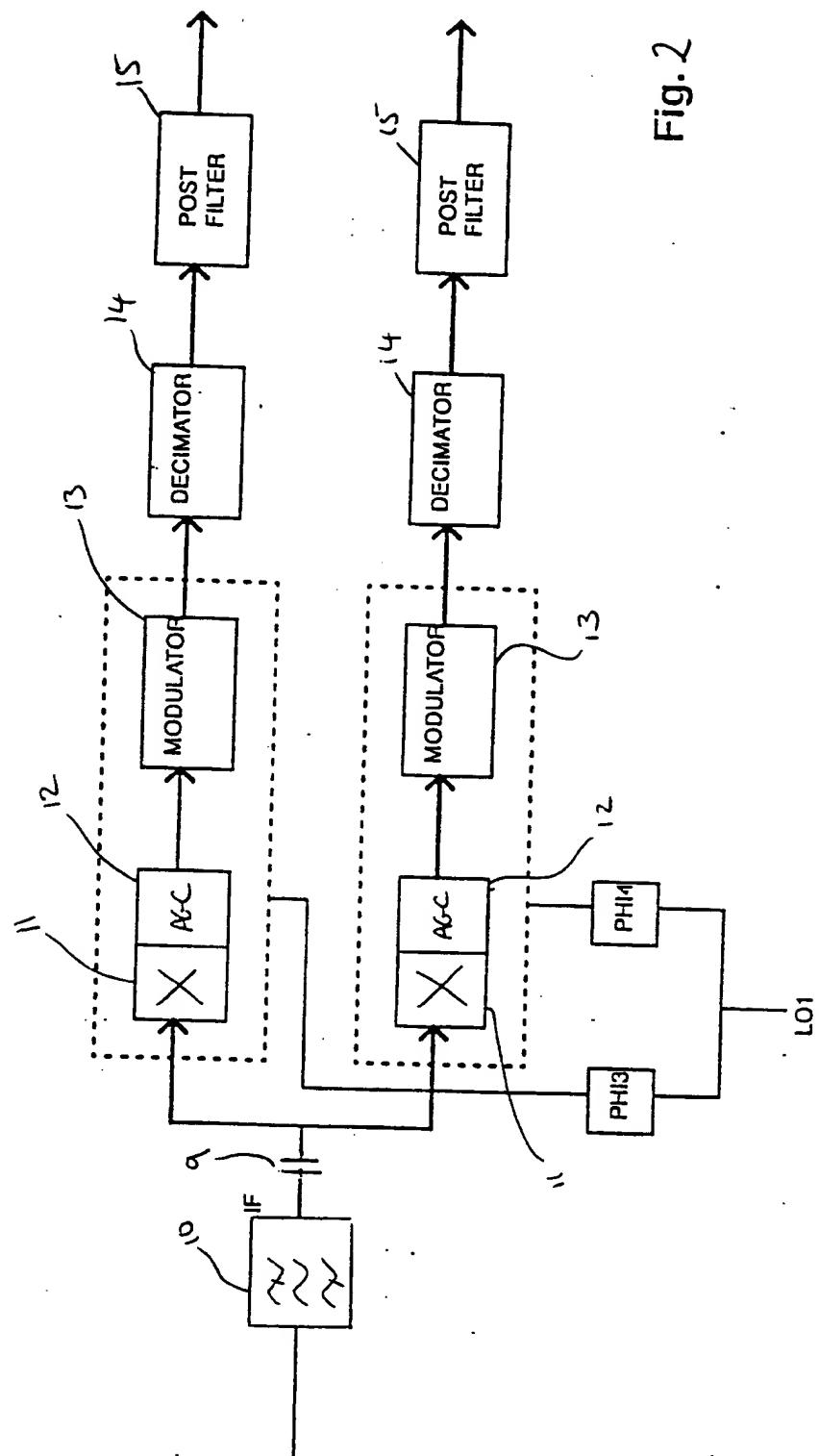


Fig. 2

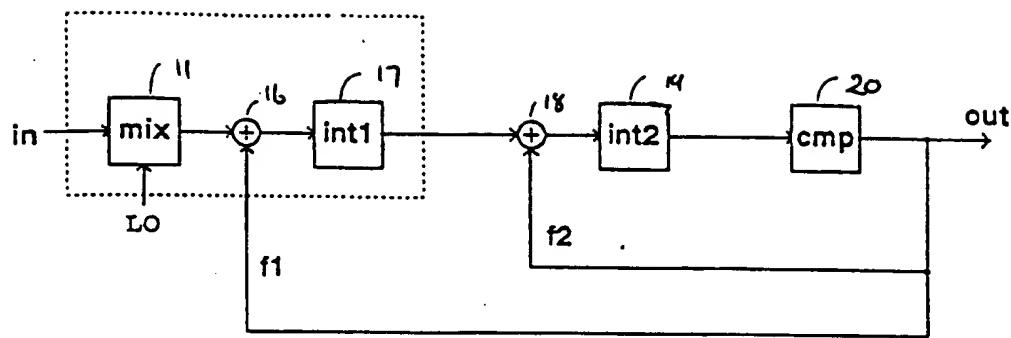


Fig. 3

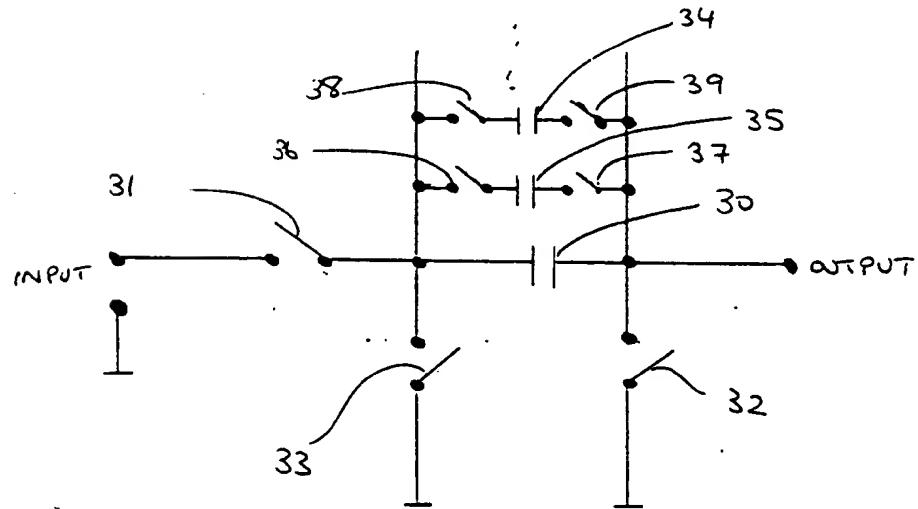


Fig. 4